APR 8 1943

Gas Journal

LIGHT - HEAT - POWER - BY-PRODUCTS

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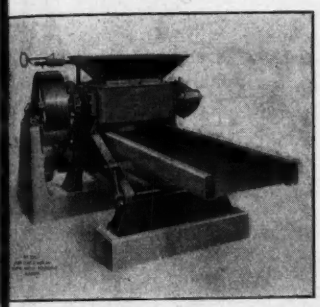
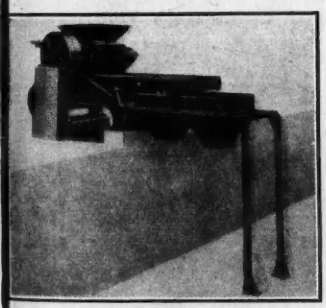
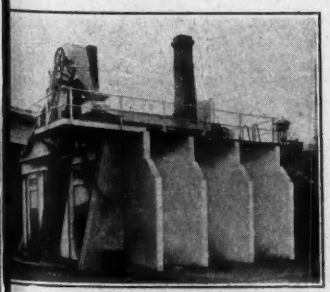


COKE CUTTING MACHINE WITH RECIPROCATING SCREEN



COKE CUTTING MACHINE SCREENING AND BAGGING UNIT



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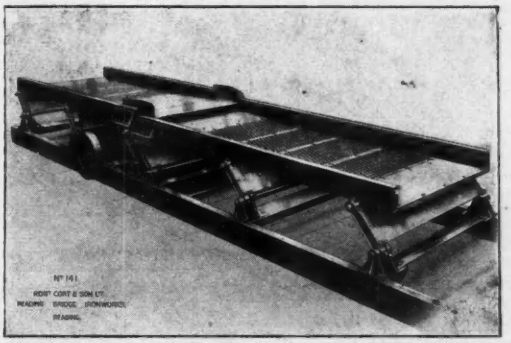

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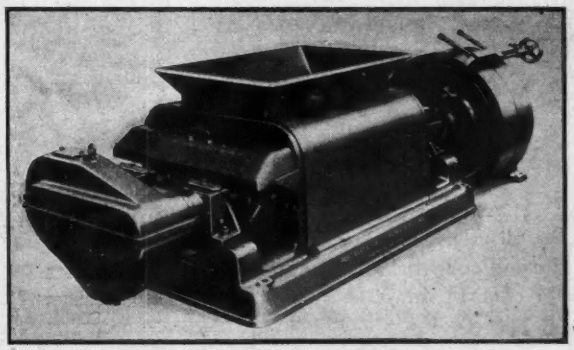

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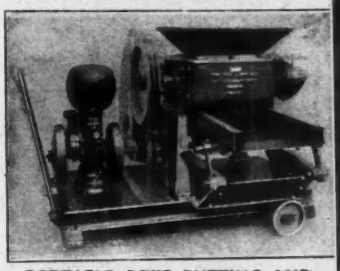

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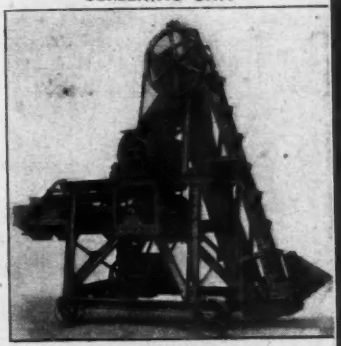

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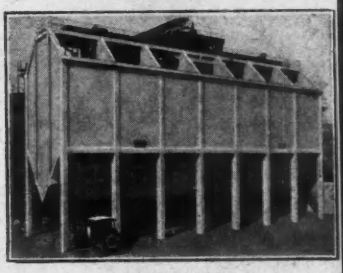

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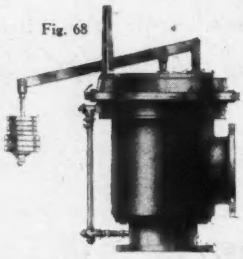

Fig. 68

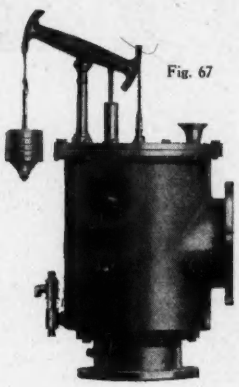

Fig. 67

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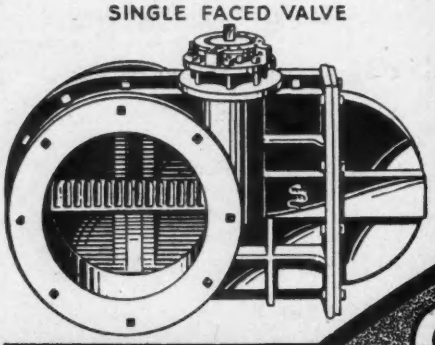

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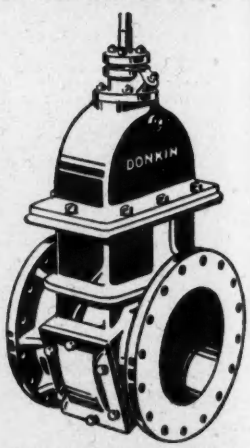

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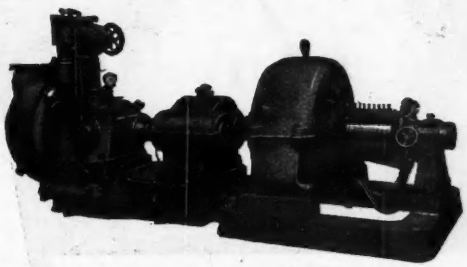

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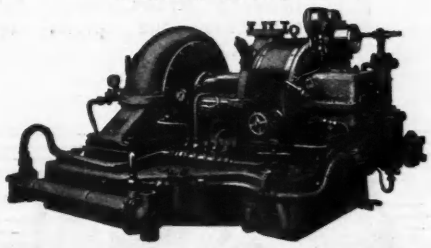

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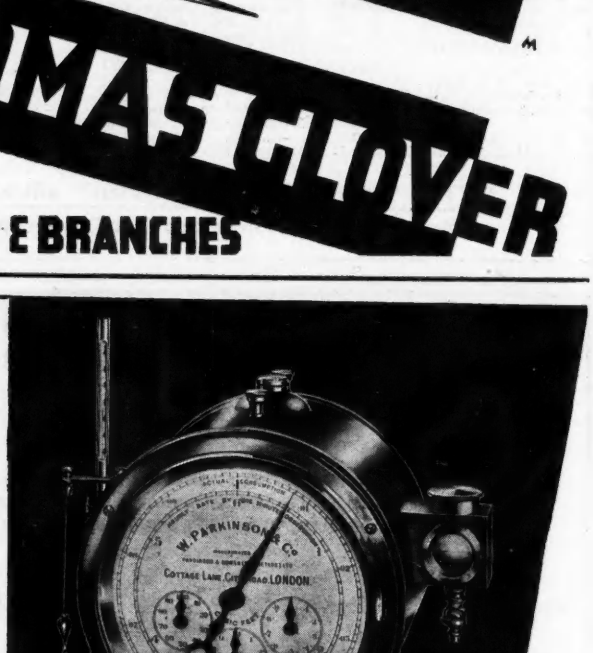

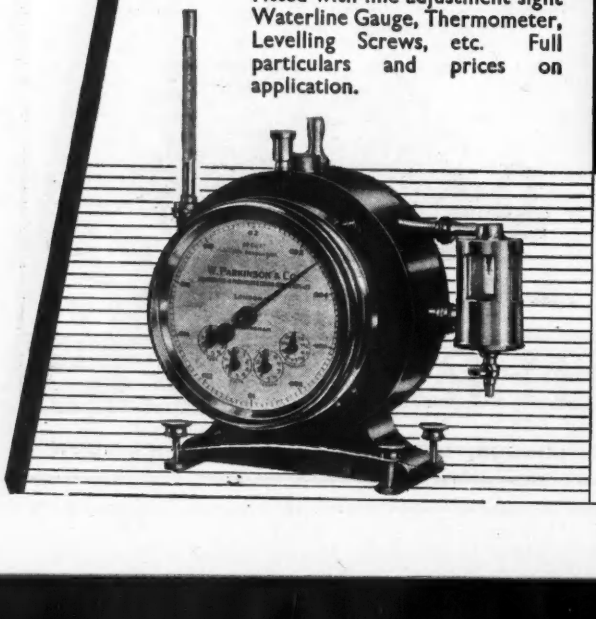

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THE SOCIETY OF BRITISH GAS INDUSTRIES · 1905 ·

P.4

GAS JOURNAL, MAR. 3, 1943

VOL. 241 95th YEAR No. 4163

EDITORIAL NOTES

GAS DIRECTORATE

IT seemed to us—and we thought the very great majority of the Gas Industry shared our view at the time—in October of 1941 that the appointment of Dr. E. W. Smith as Director-General of Gas Supply was a cause for both hope and satisfaction. As the months passed we felt that the satisfaction with the appointment of Dr. Smith increased, and that he himself had infused into others—the rank and file of the Industry, which is a useful though rather unfortunate expression—considerable optimism and definite strength "from within the Industry," among the "rank and file." Objectively we watched his strenuous activities as Director-General; we followed his work keenly and wrote about it appreciatively. As Director-General he worked hard—very hard—for an object dear to him, a fresh spirit and virility in the Gas Industry. As Director-General he wrought much.

Yesterday Dr. Smith told us that he had decided to resign his Government appointment. We are sorry to have to announce it; we think that many of those both in the Provinces and in the "greater" London area whom he has addressed untiringly during the past twelve months or so will share our view. As a result largely of his efforts the Industry seemed to be gaining a confidence in itself which scientific facts as distinct from political motives should surely justify. Through the work of the Directorate of Gas Supply an impetus had been created. This impetus must not be lost.

Yesterday, too, in telling us that his resignation takes effect as soon as suits the convenience of the Ministry of Fuel and Power, Dr. Smith said that his heart was in the Industry and for the Industry, and that call upon his services from those he has addressed will by no means fall on deaf or tired ears. And the Gas Directorate? Maybe a Phoenix will rise from the ashes. But the announcement of Dr. Smith's irrevocable decision is to us at the present juncture a cause for regret. We suggest that it is also a cause for thought within the Industry.

FUTURE OF GAS FUEL

MUCH useful information and many relevant statistics, flavoured with the spice of imaginative thought and brought together compactly and, we think, to good purpose, are contained in an article by Mr. T. A. Tomlinson which we publish in later pages of to-day's "JOURNAL." Conservation of our coal resources, coupled with the abolition of the smoke evil, which is a disgrace of our urban districts, is the theme of the contribution, and the Author forcefully advances the argument, which must receive consideration, that carbonization is by far the best and most economical way of dealing with the problem, and that gas and coke can be substituted for coal while reducing rather than increasing the amount of raw coal required. The whole domestic needs for smokeless fuels could be met either by an all-gas scheme or a gas-*cum*-coke scheme. Mr. Tomlinson adduced that the all-gas proposal would give for practically the same coal consumption an increase in the comfort standard—*i.e.*, the useful heat in the home—of over 12%, while gas plus coke would give for an increase of 12% coal consumption at least an equal increase in the standard of comfort looked at merely from the point of view of heat supply. This apart from the immense advance in convenience, in labour saving, and in smoke abatement which the transformation would bring about.

Again, can the use of gas fuel assist in the generation of electricity? Mr. Tomlinson suggested that there might be promise in such application. He visualized the employment for steam raising of a boiler such as the Velox, which with clean water and clean gas can attain an efficiency of nearly 95%. It has the remarkable feature that full output at full pressure can be obtained in a few minutes—3½ minutes has actually been cited. To what extent could this be used to counter the impossibility of storing electricity? With such an apparatus, remarked the Author, one can visualize a central power-station in which the units would be large capacity turbines, each with its own steam generator, and each capable of being brought into full operation within a matter of minutes. In such a station, combined with a large gas-making plant in which the whole of the coal would be gasified, storage would be provided for in the gasholders and the problem would be completely solved. He also suggested that the perfection in the future of the internal combustion turbine may provide another means of securing this end without the intervention of a steam generator, adding that it would appear to be possible even now to approach the solution by way of the provision of a combustion chamber placed before a gas turbine. No attempt was made in the article to consider the details of such a combination, but the notion does hold technical interest.

PROXIMATE ANALYSIS

THE proximate analysis of coal, which, if the limitations of the method are properly appreciated, is such a useful tool to the fuel technologist, was discussed at some length by the Institute of Fuel a fortnight ago, when a Paper on the subject—see last week's "JOURNAL" and our issue to-day—was presented by Mr. J. Brown and Mr. A. S. Bean, whose work on the analysis and testing of coal is well known. Some have expected too much from the simple proximate analysis and have drawn high-sounding but untenable conclusions; used with knowledge, common sense, and discretion, however, it has been and remains a valuable ally—always granted, in the first place, proper sampling of the coal, for it cannot be emphasized too strongly or too often that bad sampling nullifies the results of testing. We will not dwell on this, but there were two points in the Paper we have mentioned to which we would call attention.

The first is the Author's strong criticism of the new British Standard Specification for proximate analysis in regard to the temperature stipulated for carrying out the volatile matter test. Their argument ran thus: We have past experience of British specifications and we have the specification of the American Society for Testing Materials. The British method called for a temperature of 965°C. ± 15°C., while the A.S.T.M. method called for 950°C. ± 20°C. "In any dispute as to the correct temperature to use, the whole weight of scientific evidence was on our side, although why 965°C. should have been selected when most pyrometers read in 10° intervals we cannot think. In actual practice it matter little whichever of these temperatures be selected . . . since the coals are at or near the point at which the temperature ceases to play other than an insignificant part." The Authors went on to say how they had hoped to see the specifications of the B.S.I. and the A.S.T.M. identical in respect of this temperature, either by our going down to 950°C. or the Americans coming up to 960°C. Even as it was, so far as actual results were concerned the two were more or

less unified. "The effect of this would have been that those nations not already using 960°C. or thereabouts would have come into line sooner or later."

Alas, the new British specification reduced the temperature of the volatile matter test to 925°C., without tolerance in temperature—a reduction in temperature which the Authors regard as a major disaster. With the lower temperature, they remarked, the reduction in volatile matter will be of the order of one half of 1% at least. This, they continued, may not seem very much at first glance until one thinks of those coals that lie at the lower end of each unit rise in the scale of volatile matter. Take, for instance, the gas coals lying at the lower end of the 32% class. These must now fall into the 31% class. The lower end of the 30% class will fall into the "dreaded 29's." Gas coals are liable to complaints of low volatile matter, because, generally speaking, for any one gas coal the gas yield rises with volatile matter content. We are given to understand that whole collieries have been sampled and tested from one end to the other because of a small falling-off in average volatile matter, and we are assured that no rest has been given to anyone until the defect had been remedied—a thought which occasions us agreeable surprise. But Messrs. Brown and Bean are cast down by the new temperature for the volatile test, "which will reduce all the Durham gas coals by at least 0.5%, and thoroughly upset all statistics for no useful purpose." If allowed to remain they feel there will be a good deal of misunderstanding between producers, receivers, and analysts, and "the prospect is anything but cheerful." Considering the peculiar types of coal which gas undertakings now have, willy nilly, to carbonize, losing therms and reducing plant capacity the while, the points raised by the Authors of the Paper under review may perhaps seem rather remote and academic; but we must do our best to tighten-up practice, and in the glorious period ahead we hope that appropriate coals, appropriately cleaned, will be supplied to a tightened-up Gas Industry by technically tightened-up colliery undertakings. Admitting that the diggers of the raw material for gas manufacture hold and wield the whip hand, there is no reason why the exercise of the whip should not be under a measure of technical control.

We come to the second point in the Paper which interests us. As far as we can see it is a minor matter in the Authors' minds, but it holds significance to us quite equal to the temperature of the volatile test and the falling of coals into the "dreaded 29's." As a matter of fact it was in the nature of an aside in the Paper, and was concerned with the type of furnace—gas or electric—used in laboratory tests. First, gas "furnaces" were installed, but they were noisy and "smelly" and gave off a considerable amount of heat. So electric furnaces were tried, which were silent and did not give off heat—but frequent renewals of the heating elements were necessary, and "whatever else might be said of the old gas furnaces, they certainly would function non-stop for years and years." However, new, silent, insulated gas furnaces are now being used in the Authors' laboratories. Looking backwards, the high cost of electricity forced the designer of electric furnaces to utilize every possible unit of heat put in, which gave a furnace with the outside surfaces barely warm to the touch when in full operation. The gas engineer seems to have been under no such disability. Gas was relatively cheap, and insufficient attention was paid to design and insulation to effect economy and to ensure comfortable working conditions. The gas engineer, it is suggested, was not in the least interested in the leakage of products of combustion into the interior of the muffle. Now, in the higher temperature zones, the situation may well be reversed. The observations were concerned with a laboratory application of gas, but surely they have wider significance.

1943 "Journal" Directory

Page 86. INVERURIE. W. Gilchrist (West Wemyss), *M.*, *vice* W. Macmillan.

„ 94. WEST WEMYSS. A. Dryburgh, *M.*, *vice* W. Gilchrist.

Personal

Mr. D. V. LEWIS, Deputy Engineer and Manager to the St. Helens Gas Undertaking, has been appointed Deputy Engineer and Manager to the Salford Gas Undertaking. Mr. Lewis was trained at Widnes Gas Department, and was formerly Carbonizing Superintendent and Technical Assistant at the Stockport Gas-Works and Assistant Engineer to the Keighley Gas Department.

Obituary

Mr. WILLIAM M. RUXTON, who was Engineer and Manager to the Caernarvon Corporation Gas Department for 38 years, and who retired in 1938, died on Feb. 21.

The Examinations of The Institution of Gas Engineers in Gas Engineering (Manufacture) will be held on May 29, and in Gas Engineering (Supply) on June 6.

In Accordance with the provisions of the Town and Country Planning Act, 1943, from Feb. 10 the Ministry of Works and Buildings became the Ministry of Works.

On the Recommendation of the Gas and Water Engineer and Manager, Mr. R. O. Roberts, the Skelmersdale Urban District Council has now put into operation a modified scheme of starlight street lighting.

A Joint Meeting of the Central Executive Board of the National Gas Council and the Executive Committee of the British Commercial Gas Association will be held at Gas Industry House on March 9, at 2.15 p.m. The usual monthly meeting of the Central Executive Board of the N.G.C. will be held at the conclusion of the joint meeting.

The General Meeting of the Southern Association of Gas Engineers and Managers will be held on Friday, March 26, at Grosvenor House, Park Lane, W. 1, at 2.30 p.m., when the President, Col. F. J. Bywater, M.C., will occupy the chair. A meeting of the General Committee will be held at 12 o'clock. Luncheon will be served at Grosvenor House at 1 p.m.

A New Departure for the Home Service Department of the Bedford District Gas Company is assisting with the study of food values and their application as part of a local Unit's educational programme. The soldiers and A.T.S. concerned felt that, although the food supplied them was good, the meals they were serving lacked variety and balance, and they approached Miss Margery Davis, Home Service Adviser to the Gas Company, to give talks on food values and menu planning as a part of their curriculum. The class has formed itself into a serious study group, and is growing larger every week.

The British Laboratory Ware Association, Ltd., which has as its members the majority of firms of laboratory apparatus makers in the country, has recently formed a Technical Committee, the objects of which are as follows: (1) To promote closer co-operation between bodies responsible for the design of standard laboratory instruments and apparatus and the manufacturers of same. (2) To assist in rationalization of the design of apparatus and to eliminate overlapping, with the aim of securing economical production. (3) Collaboration to these ends with standardizing authorities, research associations, &c., in the drafting of specifications. All communications should be addressed to the Secretary of the Technical Committee at 73, Basinghall Street, E.C. 2.

A Special Demonstration supporting the Potato Campaign was arranged by the Ministry of Food and held in the Showrooms of the Oxford and District Gas Company, St. Aldates, on Feb. 11. This was the first of a series of demonstrations which the Ministry is organizing throughout the country, especially directed to commercial and industrial caterers. These were circularized, and over 100 persons attended, representing the trade or industrial canteens, municipal restaurants, &c. A number of domestic science teachers were also present. Great interest was shown in the dishes prepared by the Company's Demonstrator, Miss M. Narracott.

Dividends

Plymouth and Stonehouse.—For the half-year to March 31 next, at the rate of 3% per annum on the 3% Debenture Stock; 3½% on the 3½% Debenture Stock; 4% on the 4% Debenture Stock; 5% on the 5% Debenture Stock; less income tax at 10s. in the £.

Tottenham.—Final on Ordinary Stock 2½% actual, making 5% for the year. Final on 5% Preference Stock 2½% actual, making 5% for the year. Final on 5½% Preference Stock 2¾% actual, making 5½% for the year. All less income tax.

The fact that goods made of raw materials in short supply owing to war conditions are advertised in the "Journal" should not be taken as an indication that they are necessarily available for export.

GAS FUEL IN POST-WAR PLANNING*

By T. A. TOMLINSON, M.B.E., M.I.Mech.E.,

Chief Engineer to West's Gas Improvement Company, Ltd.

THE degree of material civilization attained by a people might perhaps be expressed as some function of the quantity of energy used per head of population, and the efficiency with which it is applied to increase the productive capacity and raise the standard of comfort of that people. Confining our attention to Great Britain we find that, apart from some small quantities of water power, our only native supply of energy is that derived from coal, and that this is supplemented by imported liquid fuel.

Coal is used either in the raw state by combustion on the spot where heat energy is required, or in steam-raising plants for the generation of electrical energy subsequently transmitted to the points where light or mechanical energy is required, or it is first treated in the processes of carbonization and gasification to produce gaseous fuel, which is very conveniently piped to situations where heat energy is required. These pre-treatment processes may be arranged to yield, in controllable quantities, a solid fuel, coke, which has a specific calorific value nearly equal to that of the original coal and which, while smokeless in combustion, possesses properties which are indispensable in certain metallurgical and other industrial processes.

According to the annual report of the Secretary for Mines of 1938, the output of coal in Great Britain was 227.02 million tons, of which 175.14 million tons was available for home consumption. The items in which we are here interested are, 14.93 million tons converted into electrical energy including that generated for railways and tramways, 18.20 million tons converted into gas and coke at the gas-works, 19.09 million tons carbonized in coke ovens mainly for the production of metallurgical coke; 97.74 million tons was used in general manufacture, including an estimated quantity of 40 million tons used for domestic purposes in private houses, domestic industries, public buildings and institutions. The total consumption of coal per head of population was 76 cwt.; it is noteworthy that this figure was 89 cwt. in 1913; 85 cwt. in 1920, falling to 66 cwt. in 1933 (due, no doubt, to the slump of 1931), and rose gradually to 79 cwt. in 1937. It is suggested that advances in efficiency in the electrical, gas, and other industries are reflected in these variations.

The approximate total quantity of liquid fuel derived from petroleum available for consumption in Great Britain and Northern Ireland was 2,768.3 million gallons. This includes 1,463.5 million gallons of motor spirit, to which should be added 105.1 million gallons of refined motor spirit, largely benzole practically all produced at coke ovens and gas-works, making a total of 1,568.6 million gallons.

The total consumption of liquid fuel is, however, only equal (at 1.6 therms per gallon) to 100 therms per head of population, a small figure, compared with the 1,140 therms of the 3.8 tons of coal, when one considers the immense influence which the internal combustion engine has had on communications and transport by road and air.

We have thus an approximate figure of 1,240 therms as the quantity of energy used per head of population for all purposes, but it is not proposed even to hazard a guess at the overall efficiency with which it is used.

Apart from its use at the collieries and by coasting steamers, the coal available for home consumption is applied in three main fields:

(i) Domestic.
(ii) Power generation.
(iii) Industrial (mainly iron and steel production).

I. Domestic

Dr. Hartley (Inst. Gas E., Com. No. 248, 1942) gives the following estimate of the "fuel derived from natural sources, which is used only in the homes of the people of Great Britain," to which is added the second column giving the estimated quantity of coal used in production of gas and electricity.

Fuel.	Quantity used.	Coal expended. Million tons.
(*a*) Coal	35 million tons ...	35
(*b*) Anthracite ...	1 ,, ...	1
(*c*) Coke	2½ ,, ...	—
(*d*) Coalite	½ ,, ...	0.65
(*e*) Town gas	210,000 million cu.ft. ...	12.35
(*f*) Electricity	7,500 million units ...	5
Total		54

The coke is not included in the total because it is itself a product of the gas-works process, and therefore covered by item (*e*).

Coal is classified under several systems for scientific purposes, but we need not concern ourselves with these here. For the present purpose we may adopt the classification of a recent Fuel Research Board publication (Survey Paper No. 55).

	Volatine content %.
Anthracites	5 to 9.5
Steam coals (carbonaceous and semi-bituminous) ...	10 ,, 23
Bituminous coals—	
Coking coals	23 ,, 30
Gas-making coals	30 ,, 40

The percentages are expressed on the dry ash-free coal.

Anthracites and steam coals burn without smoke, but bituminous coals when burned in the raw state, and without special precautions, give rise to the smoke pall which is the disgrace of our urban districts. Unfortunately, most of the 35 million tons of raw coal burned in the domestic grate is in the bituminous class, and the only way to remove this blot on our civilization is to abolish the use of raw coal altogether in the domestic grate.

Carbonization is by far the best and most economical way of dealing with this problem. Gas and coke would be substituted for coal, and this can be done without any increase in the gross weight of coal used. Taking round figures, the calorific value of one ton of bituminous coal is 300 therms (1 therm = 100,000 B.Th.U.). The efficiency of utilization of raw coal in the domestic grate is not more than 20%, so that 60 useful therms are derived from the combustion of one ton of raw coal. Carbonized by the ordinary gas-works process, this coal produces 80 therms of gas, and, say, 12 cwt. of coke, of which 4 cwt. is used in the process and lost in various ways, leaving 8 cwt. available for use in the home.* The efficiency of utilization of the gas is at least 50%, and that of the coke somewhat more than that of raw coal (say, 28%), so that 40 useful therms are derived from the combustion of gas in the home, and 30 from that of the coke, a total of, say, 70 useful therms, saving 16% in the consumption of raw coal. These fuels are consumed without smoke.

To replace the whole of the raw coal consumed in the home by smokeless fuels would obviously require an immense extension of existing carbonizing plants. Taking Dr. Hartley's figures, we may say that 12 million families are using 1,000 million gross therms of gas, equivalent to 500 million useful therms, and 39 million tons of solid fuel which we may evaluate at 12,000 million gross therms, equivalent to 2,400 million useful therms, a total of 2,900 million useful therms, or about 240 useful therms per family. This figure is probably too low for the modern standard of comfort, and estimates should be based upon 275 or 300. On the other hand, not all of the 12 million families are within reach of gas supply. It is estimated that about 10,700,000 families are now connected. It should be possible to increase this to 11 millions within the very near future. The total demand, therefore, would be between 3,000 and 3,300 million useful therms. We may take the smaller figure as the basis of calculation because it will take time for the public to be educated up to the higher standard of comfort implied by the greater figure, a development which may be pursued, as will be shown later, without fear of materially increasing the gross consumption of coal.

Leaving other possible solutions of the problem out of consideration, the whole domestic requirement for smokeless fuels can be met either by supplying all gas or by supplying gas and the coke of the carbonization process.

If the former proposal were to be adopted it would be necessary to change the present gas-works process to one in which the whole of the coal is gasified. Without going into the possibilities of new processes which are not yet ready for exploitation, it is suggested that coal would be carbonized in some such apparatus as continuous vertical retorts with "steaming," in which gas can be made at any desired calorific value within certain limits. The residual coke would be sent forward to water-gas plant and completely gasified. Part of the water-gas would be used for heating the retorts of the carbonizing process and the balance would be fed into the coal-gas stream. The result would be the production of approximately 150 therms of gas with a calorific value of 400 B.Th.U./cu.ft. At 50% efficiency of utilization this would be equivalent to 75 useful therms. At the rate of 275 useful therms, the carbonization of 3.67 tons of coal per family would meet the demand.

On the other hand, there are strong grounds for the retention of one solid fuel fire in the home. A sub-committee of The Institution of Gas Engineers in their Report on Coke Quality (1942) said "that for some time to come the policy of the Gas Industry will be to develop as a two-fuel industry," because—

> "(1) It must be many years before research now being conducted reaches such a stage that large-scale complete gasification will replace the present systems of carbonization.
>
> "(2) It is unlikely that the British public will give up solid-fuel fires unless compelled to do so."

It cannot be too strongly emphasized, however, that this must not give rise to the emission of smoke. We can, therefore, visualize a large number of cases in which fuel is supplied to the home partly in the gaseous form and partly in the solid form, that is, in a combination of gas and coke. So great an extension of the gas supply industry as would be involved in the proposal to eliminate the whole of raw coal from domestic use might well result in grave difficulties in the disposal

* Paper to the Institute of Fuel.

* For general information on efficiencies of utilization of the several types of fuel, see C. A. Masterman, "The Future of Gas Appliance Design," Comm. No. 158, *Proceedings of The Institution of Gas Engineers*, 1937, p. 1027ff.

of coke, unless the proportion of gas to solid fuel used corresponded fairly closely with the proportion in which they would be available for sale at the gas-works. We have assumed that that proportion would be roughly 80 therms of gas to 8 cwt. of coke. The requirements would be satisfied by the supply of approximately 320 therms in gas and 32 cwt. in coke, requiring the use of four tons of coal per family.

What would need to be the capacity of public gas supply to meet the demands of 11 million families in these two forms?

The all-gas scheme would require the complete gasification of 40.4 million tons of coal. In 1938, gas-works gasified 18.20 million tons, of which, as we have seen, 12.35 million tons were accounted for by the domestic demand for gas, leaving 5.85 million tons for the industrial gas demand. Assuming for our present purpose that the industrial demand remained constant, we should have to gasify, say, 46 million tons of coal per annum.

The gas-cum-coke scheme would require the use of 44 million tons of coal, which, added to the 5.85 for the industrial demand, would make a total of, say, 50 million tons.

It may be taken, therefore, that to replace the whole of the raw coal now consumed in the domestic grate would require the multiplication of the Gas Industry at least 2½ times.

Reverting to Dr. Hartley's figures, the 1938 domestic coal consumption was 54 million tons. The 5 million tons supplied in the form of electricity may be regarded as likely to represent the irreducible minimum for domestic light and power. The million families not connected to the gas supply system may be assumed to consume 4 million to 5 million tons of coal. If the balance were completely replaced by gas, or gas and coke, the total requirements would be 50 or 55 million tons respectively. That is to say, the all-gas proposal gives for practically the same coal consumption an increase in the comfort standard from 240 to 275 useful therms per family, or 12½%, while gas plus coke gives, for an increase of 12% coal consumption, at least an equal increase in the standard of comfort looked at merely from the point of view of heat supply.

It is not necessary to dilate on the immense advance in convenience, in cleanliness, in labour-saving, in smoke abatement which such a transformation in fuel-consuming habits would bring about. So great is this advance that, in the writer's view, it would be worth a considerable increase in the cost of fuel supply.

Can the consumer afford this luxury? The answer depends on a number of economic factors which are mostly outside the scope of this paper. It can be said, however, that, whereas the average family spent in 1938 about £14 per annum on fuel, excluding electric light and power, the 550 therms (275 useful therms) we have in mind could be supplied for the same expenditure at the rate of 6d. per therm, which, in view of the greatly increased demand which is visualized in this revolution, is a figure well within the bounds of possibility.

The heat supply to the average family to sustain a standard of comfort equal to that now only found in the middle-class home could be met without any serious increase in annual expenditure on fuel by the supply of either 550 therms of gas or 320 therms of gas with 32 cwt. of coke. It should be possible to add to this at least 1,000 units of electricity for lighting and power without serious embarrassment to the family income.*

There are many directions in which further economies can be effected in the gas consumption of domestic services. The reduction of organic sulphur to a negligible percentage is a development which it is confidently anticipated will be realized within the next few years. This, apart from the consequent reduction in the cost of maintenance of appliances, will render possible several forms of flueless gas radiators with an efficiency of the order of 90%. The convector type of gas radiator will have an efficiency of 60%. Several forms of water-heating apparatus are already in practical use with efficiencies of 60 and 70%. The overall efficiency of gas utilization can, therefore, be expected to be raised to over 60% in the not far distant future (see Hartley, *loc. cit.*).

II. Power Generation

Mr. A. Stubbs, of Messrs. Metropolitan-Vickers, has summarized the modern view on this subject in an excellent Paper, "Fuel and Power Generation," reported in the *Journal of the Institute of Fuel*, December, 1937. He points out that the emission of smoke, grit, and sulphur from the chimneys, whether of the locomotive on our railways or of the electric power-generating station, is regarded as an intolerable nuisance by the public. At the great Battersea power station it has been necessary to install purification plant for the waste gases from the giant boilers, and this plant occupies a considerable portion of the site.

With regard to the nuisance arising from the filth scattered over our countryside and in our towns and cities by the railway locomotive, Mr. Stubbs points out that "There is sufficient evidence already to indicate that the . . . solution lies in the wholesale electrification of the railways." The aeroplane is cited as a modern means of transport which has always demanded a specialized fuel—in this case in liquid form, "refined and doctored,"—to attain the best possible performance of the aero-engine.

Central power-station efficiency has already reached a very high figure. At Battersea the expenditure of coal per unit sent out is as low as 0.97 lb. But there is an upper limit to the efficiency of the steam cycle. "The size, specific capacity, and efficiency of boilers and turbine plant have been continually improved." But if further significant progress is to be made, the boiler must be fed with pure water heated by the combustion of a clean fuel. "Raw coal presents many problems. The ash may be more or less fusible; it may give trouble on the furnace wall or form bird-nests on the boiler tubes; it may pass through the boiler to foul the flue-gas passages or it may create nuisance when it passes out of the chimney. It is clear that coal is not the most desirable fuel, and that many of the difficulties of power-plant design and operation would disappear if oil or—better still, gas—were available. The combustion of clean gas is by far the most simple process. It need not present any difficulties." Mr. Stubbs goes on to the statement "that certain forms of power plant are only possible with clean fuels," and instances the Velox steam generator. The appearance and development of this apparatus is an event of the most significant importance in the history of power generation. Introduced by the Brown-Boveri Turbine Works, Switzerland, it was described by their chief engineer, Mr. A. Meyer, in a paper published in the *Journal of the Institute of Fuel*, August, 1934.* It is a boiler with a super-charged combustion chamber, in which the fuel is consumed at pressures of three or four atmospheres, and in which both water and gas pass over the heat-interchanging surfaces at very high speeds, and it attains thermal efficiencies reaching nearly 95%. But perhaps its most remarkable feature is the exceedingly short time required to bring it into operation. Only 3½ minutes was required in a cited instance to obtain full output at full pressure from a cold start. It is this quality of the Velox boiler which enables it to solve another problem of electricity supply, that of the practical impossibility of storing electricity in large quantities. It is this difficulty which has driven electric supply undertakings into schemes for disposing of current in off-peak periods at uneconomic rates which upset the market for other and more suitable forms of energy.

With some such apparatus as the Velox steam generator one can visualize a central power-station in which the units would be large capacity turbines, each with its own steam generator, and each capable of being brought into full operation within a matter of minutes. In such a station, combined with a large gas-making plant in which the whole of the coal would be gasified, storage would be provided for in the gasholders and the problem would be completely solved. The perfection in the future of the internal combustion turbine may provide another means of securing this end without the intervention of a steam generator. It would appear to be possible even now to approach the solution by way of the provision of a combustion chamber placed before a gas turbine. In any case, Mr. Stubbs' conclusion would appear to be irresistible that "further specialization in fuel . . . may be expected to continue and that purified coal gas would be an ideal fuel for power generation in this country." The combined gas and electricity station for a maximum hourly generation of 50,000 kw. would require a gas-works of about 48 million cu.ft. daily capacity making mixed coal and water-gas at a calorific value of 370 B.Th.U. per cu.ft. on the lines suggested. Recent estimates have indicated that such a combined station conceived on conventional lines might be expected to produce energy at a slightly lower cost than by the direct use of raw coal. The use of the gas turbine might reduce the cost still further.

No attempt is made here to consider the details of such a combination, but it may be said that even if it does not hold out, with established processes, any great hopes of economy in coal, it does offer a complete solution of the problems of the emission of smoke, grit, and sulphur, which are such troublesome features of the existing power-generating station. The proposal so far assumes the availability of adequate supplies of bituminous coals. Where these are not sufficiently available the carbonizing process might be dispensed with and low volatile coals gasified in producer or water-gas generators.

III. Industrial Fuel

By far the biggest single item of coal consumption in industry is that used in the manufacture of iron and steel, which in the 1938 return is debited with 18.74 million tons. General manufactures and all other purposes (including domestic use) is debited with 97.74 million tons, and if we deduct the 40 millions allocated to domestic purposes, we obtain a "residuary figure" of 57.74 millions for other industrial purposes.

It was estimated that at Skinningrove† the equivalent of 34.99 cwt. of coking coal was consumed in the production of one ton of pig iron, and 37.14 cwt. in the production of one ton of steel ingots, including the former figure, in a works where blast-furnace gas and the residual gas of the coke ovens were fully employed in the steelworks.

	£	s.	d.
* 320 therms at 6d.	8	0	0
1.6 tons coke at 44s.	3	10	5
1,000 units at 0.8d.	3	6	8
Total annual charge per family	£14	17	1

* A recent article in the *Engineer*, October 30, 1942, "The Present-Day Design of the Velox Boiler," shows that even with oil-fuel there still remain slagging problems due to impurities. These would be obviated entirely with a clean gaseous fuel.

† "Developments in Fuel Economy at Skinningrove," Frank Bainbridge, Iron and Steel Institute, 1930. (See *Engineering*, May 9, 1930, p. 617.)

Coal is used in the steelworks for the production of the hard, strong coke suitable for the blast furnace and for the generation of producer gas consumed in the conversion of iron to steel. The total coal required to convert pig iron to steel ingots was given by Mr. Bainbridge as 2.40 cwt. per ton of ingots.

Hard coke is, however, used in a number of other industrial processes, and even at Skinningrove 3,000 cu.ft. of residual gas per hour was available for sale to the local gas undertaking. In 1938 by-product coke ovens carbonized 18.80 million tons of coal, making 12.64 million tons of coke and 1.03 million tons of breeze. The residual gas amounted to 198,418.5 million cu.ft., of which 28,997.6 million cu.ft. were sold to gas undertakings, according to the 18th Annual Report of the Secretary for Mines. The Board of Trade (Gas Undertakings) Return for 1938 gives 29,620 millions.

In 1930 a Departmental Committee of the Board of Trade reported on the possibilities of area gas supply utilizing surplus coke-oven gas, arising out of a statement made by the National Fuel and Power Committee in their Report of 1923 that "proposals are often made for the use of coke oven gas for town purposes which involve transmission of the gas over considerable distance in pipe lines." The Committee was appointed to consider whether there were any areas in this country where a gas grid could be profitably set up. Dr. E. W. Smith, now Director-General of Gas Supply, acted as Technical Adviser and was responsible "for the vast amount of technical work arising out of the enquiry."

The Committee came to the conclusion that it was only in the South Yorkshire area that there was a sufficiently dense concentration of fuel-using industry to promise an economically sound exploitation of a gas grid based on surplus coke oven gas. In this area it was found that there were only seven cases in which coke ovens were on the same site as blast furnaces. In all other cases distances between them varied from one or two miles to 25 miles, and in one case 60 miles. But all the ovens are situated on the coalfields and generally at or near the collieries. They found "two schools of thought, one that holds the view that the future development of the iron and steel and coke industries is that they will be reorganized on the lines of large installations on the coast, comprising coke ovens, blast furnaces, steelworks, rolling mills, &c., on the same site using high-grade, imported ores, and the other that holds the view that any departure from the present practice, under which . . . the coke ovens are at the collieries and not at the steelworks, is improbable in this country." And the Committee agreed with the latter view.

Following page 57 of the Report will be found a map showing the area in which the development they recommend would be situated and the run of the network radiating from Sheffield and Rotherham. This scheme is already in process of development; it was estimated that the volume of surplus coke oven gas would rise to 80 million cu.ft. per day in that area alone.

Coke ovens are designed and operated primarily from the point of view of coke production, so that it is not surprising that the yield of gas per ton is not so high as that from gas retorts. The computations in the Report to which we are referring are based on a yield of 11,500 cu.ft. of debenzolized gas at the calorific value of 520 B.Th.U. cu.ft., equivalent to 60 therms per ton.

This gas is used as follows:

(1) Underfiring, 5,200 cu.ft. = 27 therms.
(2) Boilers, &c., 865 cu.ft. = 4.5 therms.
(3) Surplus, 5,435 cu.ft. = 28.5 therms.

Transmission of purified gas over distances up to 40 miles is perfectly feasible, and the Committee saw no technical difficulties in the way of the realization of their proposals.

The convenience of control and cleanliness of operation of gaseous fuel, which has already been noted in connexion with the highest forms of modern steam-raising, has commended this type of fuel to many industrial processes. And the phenomenal expansion of the production of munitions of war has only increased a demand for gas which was assuming notable proportions before the war. From 10% to 30% or 40% of the gas sold by undertakings serving industrial districts was already absorbed in several thousands of industrial processes, and both the volume and variety of these have increased to proportions which have not yet been actually recorded, and could not be published if they had. Gaseous fuel lends itself so obviously to thermostatic control, to equal distribution throughout the combustion chamber, to adjustment of atmosphere as between oxidizing and reducing characteristics, that it was inevitable it should be indispensable in many problems in the heat treatment of the alloy steels which enter so largely into modern machinery, whether of war or peace. It is almost the only fuel used in the glass industry, and the use of clean gaseous fuel in the pottery industry effects a considerable economy by the obviation of the necessity for saggers. And in several thousands of industrial processes which can be found listed elsewhere gaseous fuel has superseded solid fuels with advantage and economy.

The Gas-Fuel of the Future

This increasing use of gas-fuel in many processes requiring precision heating has led to a reconsideration by gas engineers of the standards of purity which must be attained by town gas in the immediate future. Arising out of a symposium, entitled "The Gas Industry: 1941 and After," presented to The Institution of Gas Engineers in that year, a number of sub-committees were set up to investigate the possibilities of technical improvements over the whole Industry. Two of these were concerned with gas quality. One investigated the standardization of the calorific value and other physical properties of town gas and the other, the removal of organic sulphur.

Their recommendations have now been published. Calorific value, specific gravity, and combustion characteristics are dependent upon the coal carbonized and the processes used in its gasification. It was agreed that it was impracticable to adopt a standard calorific value over the whole country, and it was recommended that the present freedom of choice of calorific value be maintained, but that interlinked undertakings (the number and extent of which are likely to be greatly increased in the post-war period) should be regarded as one undertaking from this point of view, that is to say, the calorific value would be standard over wide areas. The committee urged the "pressing need for a stricter control of gas quality and of distribution practice within the ambit of each undertaking." Evidence showed, however, "that the greatest cause of complaint by the consumer is excessive variation in gas pressure at his appliances," and the committee recommended control within narrow limits of such variations.

Sulphur removal is a question which has agitated forward-looking men in the Gas Industry for a long time. H_2S is completely removed from town gas before distribution, but as much as 25 grains of organic sulphur per 100 cu.ft. may be left in. Sulphur in this form gives rise to corrosion of appliances and also to difficulties in the heat treatment, particularly of some non-ferrous metals, and other industrial processes. It has been shown that corrosion of appliances practically disappears when organic sulphur is reduced to 8 grains, but that the "ultimate objective of the Gas Industry should be to secure a sulphur content not exceeding 3 grains per 100 cu.ft." It is recommended that "as a first step the organic sulphur compounds in all supplies of town gas should be reduced to 10 grains, which can be done by processes which have been proved by experience," and at so low a cost as to be covered by the saving in maintenance of appliances, and in any case, to be negligible. But "in view of the advantages which accrue when the sulphur content is reduced to 3 grains per 100 cu.ft., gas undertakings should be encouraged to make better use of the facilities available to enable them to attain this lower limit," the total cost of which is not likely to exceed 0.22d. per therm.

It may be taken, therefore, that the town gas of the immediate future will be standard as to calorific value over wide areas, that pressure variations will be reduced to a very low minimum, and that it will be practically free from sulphur. The Gas Industry is fully alive to the necessity of reaching this standard of service and purity if gas-fuel is to take its rightful place in the supply of fuel in every suitable domestic and industrial field.

Conclusion

An attempt has been made to show that the substitution of gas-fuel for raw coal offers a solution of one of the major problems of our British civilization, that of the removal of smoke from the atmosphere of our cities and towns, now principally due to the domestic chimney, with its attendant ills of waste, dirt, unnecessary labour, and pulmonary disease. And that the standard of domestic comfort from the point of view of heat supply can be sensibly raised in this way without any corresponding increase in coal consumption or relative expense.

The domestic economy is not complete without a supply of electricity for lighting, for the radio, and for many labour-saving, portable heating, and other devices. In the generation of electricity, gas-fuel promises a further advance in thermal efficiency coupled with the obviation of the dust and sulphur nuisances now associated with the super-power station.

No attempt has been made to explore other means by which this problem might be solved in part and in certain favourable localities, as, for instance, by communal supplies of hot water distributed from central thermal stations.

Finally, while some of the characteristics of the gas-fuel of the immediate future have been touched upon, no attempt has been made to foreshadow more remote developments. The laboratory stage of a process in which coal will be gasified under pressure has already been passed, and apparatus of a semi-industrial character is erected or in process of erection. These efforts are hidden by the fog of war. In any case, it is clear that several—perhaps a good many—years will pass before these methods come to fruition. When they do, it may be that both gas and oil fuel will be replaced by liquid methane. In the meantime processes already known and practised are being developed and improved to attain the highest possible level of efficiency. In all these efforts to solve our fuel problems it is most desirable to bear constantly in mind that though we are blessed with a supply of coal which will last us for a very long time to come, it is a wasting asset, not only from the point of view of quantity, but in that as we dip into it we bring it to the surface at a steadily increasing cost. Already some of the richest seams are exhausted, and we are now working thinner seams than is usual in other great countries of the world.

PROXIMATE ANALYSIS OF COAL*

By JOSEPH BROWN, M.Sc., and ALAN S. BEAN, M.A.

(*Continued from p. 255*)

(3) *Testing Samples in Batches.*—It is always as easy to do two of a thing as to do only the one, and this applies no less to the analysis of coal. For multiple testing it is unthinkable to have large numbers of individual bottles littered about the benches awaiting test, for sooner or later confusion is certain. They are therefore made up into batches and packed in specially made boxes. An aperture is left at the end of the long side of each box for removal of the bottles one at a time. The optimum size of a batch is a rather nice point. We have tried 24 in each batch, but for coal work this is now reduced to 12, mainly with the object of reducing the size of the equipment components and partly to provide more frequent "breathing intervals" for the staff. Each box of 12 samples has, of course, its twin component. We have a 24-batch system working in another department and are comparing the two with great interest. We may end up with equipment sufficiently elastic to work with 6, 12, 18, or 24 batch systems.

(4) *Weighing.*—An obvious bottleneck in analysis, whether of the intermittent or of the multiple type, is the time taken up in weighing, all to be paid for at so much per hour, and it is many years ago now since we abandoned the swing type of balance for continuous routine work. The balances we use are exclusively the Oertling air-damped Aperiodic Model, No. 52 GB. with side action. No weights are used below 0.5 gramme, and the illuminated scale reads 1 milligramme per division, and can easily be read to $\frac{1}{5}$ milligramme, which degree of accuracy is more than ample for the requirements of the proximate analysis. A skilled operator who means business can weigh dishes or crucibles, then add a weighed quantity of coal at the rate of 24 to the half-hour with ease. We cannot speak too highly of these balances and those who use them so well.

(5) All dishes and crucibles are moved about in batches on trays or in other handy containers, so that where the student thinks of one test, we always think in terms of 12 or 24 tests carried out simultaneously in not much longer time.

(6) The volatile matter test is carried out in pyrometer controlled furnaces using silica crucibles. The furnaces used must have large reserves of heat within them so that the fall in temperature is not more than about 10°C. when the cold crucibles are put in. The silica crucibles are those specified in earlier B.S. Specifications. They are used in batches of two or four, but we have never been able to obtain satisfactory results using more than four at a time. We use two at a time to give us a factor of safety for certain special samples. The silica crucibles are carried in stainless-steel supports, which have low heat absorption, and last for years in the reducing atmosphere created in the volatile test. They are easily made, or can be purchased for a few shillings. We have used them in our work for over 12 years. The whole of this technique is controlled by means of the platinum crucible or American method, applied at intervals.

To illustrate the effect of the proposed reduction in temperature for the volatile test, we have asked one of our lady operatives to carry out a series of duplicate tests, reducing the temperature of the muffle furnace from 960°C. in steps of 10deg., and to check the results all the way by means of the American method, carrying out this control test in duplicate also, but making only one test at a time instead of two. She had no inkling of our purpose, and the results given in Table I are a faithful record of her work.

TABLE I.—COAL No. 4C/7849. VOLATILE MATTER LESS MOISTURE. MOISTURE 2.05%.

Temperature, °C.	Silica crucibles, 2 at a time. A. %	B. %	Difference. %	Platinum crucibles, 1 a a time. A. %	B. %	Difference. %	Reportable means. Silica. %	Platinum. %
960	31.50	31.30	0.20	31.53	31.60	0.07	31.4	31.6
950	31.45	31.40	0.05	31.40	31.43	0.03	31.4	31.4
940	31.10	31.20	0.10	31.30	31.27	0.03	31.2	31.3
930	31.20	31.05	0.15	30.80	31.10	0.30	31.1	31.0
920	30.40	30.95	0.55	30.80	31.10	0.30	30.7	31.0

Analyst, Rhoda Thompson. Checked and approved, J. W. Birney, B.Sc., Analyst-in-Charge. Jan. 18, 1943.

We have, of course, carried out this type of series tests on many other occasions, but prefer to bring before you information that is as recent as it can be in the circumstances. From the results two very important observations can be made:

(i) The reduction in volatile matter is far from being negligible, and for this coal amounts to 0.7%. The coal in question was a Durham gas coal of the 31% volatile class. The results of the analysis were sent forward to the receiver—a small gas-works with no laboratory facilities—through the medium of a distributor, to demonstrate that the consignment was of the correct quality. This particular gas-works likes the coal to have not less than 31% of volatile matter. The new volatile matter would be 30.7%, which means that the coal will be reduced in status.

(ii) The American or platinum crucible method shows great concordance in the higher temperature range, and in this respect is always fractionally better than the silica crucibles, which, in their turn, behave very well at the higher temperatures. It is very noticeable that below 940°C. both the silica and platinum crucibles begin to yield discordant results. Now a routine feature of the operation of our system of carrying out proximate analyses is that when two independent tests are discovered by records to differ by more than the tolerances we have fixed, then their duty is to see that the samples are exchanged-about between the operators and retested. The liability to find ourselves testing samples over and over again is another reason why we find 925°C. unacceptable.

Low Volatile Coals, including Anthracites.—It is well known that the non-caking coals are the most difficult of all to handle in the volatile matter test, and the B.S.I. have quite rightly isolated these for testing by special methods whereby oxidation or loss by decrepitation are minimized. We use special measures for these coals ourselves.

(7) *Furnaces.*—We have always been willing to try anything once, and at one time or another we must have tried all makes and shapes of laboratory muffle furnaces, including many of our own design, manufactured in our own workshop.

First we had gas furnaces, but—

(1) The noise,
(2) The smell,
(3) The heat,
(4) The destructive effects on their immediate surroundings,

drove us away from them, and for a long time we were "all electric." The electric furnaces had the very desirable features of—

(1) Complete silence.
(2) Ease and accuracy of control.
(3) Negligible radiation to surroundings.
(4) Diminished effect on laboratory atmosphere.

Nichrome wound electric furnaces are very pleasant to use and quite reliable provided the temperature asked of them is not too high. When asked to perform regularly at temperatures much in excess of 900°C. their reliability is badly shaken, and, although much improvement has been made in the quality of nichrome wire, fairly frequent renewals are necessary. We need hardly add that the failures always occur just at those times when they are least desired. Whatever else might be said of the old gas furnaces, they certainly would function non-stop for years and years.

Since the possibility of this Paper was first broached we have had the good fortune to become impressed by the work carried out by Mr. Hellewell, of the Londonderry Collieries, Ltd. (Co. Durham), on the insulation and flue design of multiple gas muffle furnaces. Mr. Hellewell has put much patient work into the construction of these furnaces, the object being to utilize the waste heat from muffles running at high temperatures to heat muffles running at lower temperatures, the final hot gases being used to make distilled water or for heating small ovens. The muffles are built up in two vertical piles. We have constructed two multiple muffle gas furnaces on the same principles and the results are quite remarkable. The first "Hellewell" type of furnace constructed uses 10 bunsen burners to heat 9 muffles (size 10 in. by 7 in. by 2 in.) to temperatures varying up the furnace from 960°C. down to about 500°C. for the uppermost muffles. The consumption is only 26 cu.ft. per hour when running with the burners adjusted to silence, and it reaches operating heat in less than 20 minutes. The second attempt uses only 8 bunsen burners for the same job. We have a third furnace under construction and hope to carry out with it the whole of the operations of the proximate analysis —including the moisture and many other laboratory operations in addition. But more of this perhaps another day.

The prognostications are that the whole load will be carried by about 1,000 cu.ft. per week at 475 B.Th.U. The same job, using electricity, requires about 23 amps. at 250 volts, equalling not less than 250 units for our working week. Looking backwards, it is easy to see how the prohibitive cost of electricity in earlier days forced the designer of electric furnaces to utilize every possibly calorie of heat put in, which gave a furnace with the outside surfaces barely warm to the touch when in full operation. The gas engineer seems to have been under no such disability, the result being a hot, smelly furnace. He often omitted to provide a door, and was not in the least bit interested in the leakage of products of combustion into the interior of the muffle. So they went out of fashion. Now, in the higher temperature zones, the situation may well be reversed, although, in other spheres of laboratory work, electricity, by virtue of its exquisite accuracy of control, will certainly take some dislodging.

(8) *Operators' Working Notes.*—When establishing an organized method of carrying out analyses in large numbers, an essential part of the job is the organization of the method of recording the details and results of the individual tests as they are being carried out. For the research worker or the single-handed analyst the plain notebook, in

* From a Paper to the Institute of Fuel, Feb. 18.

which all results and observations are recorded, is quite adequate; but when a number of people participate in an analysis, and other members of the staff may wish to follow the progress of the work, something a good deal better is required. Notebooks that can inadvertently be carried out of the laboratory while containing much-needed results, or, even worse, that all too handy piece of scrap paper, become a definite menace. The proper organization of the method of recording the results of the work deserves at least as much study as the organization of any other part of the work. For this purpose we use printed cards and printed worksheets. As far as possible, different colours are used for different classes of work. Printing is always cheaper than writing for repetition work, and every word of writing or typing that can be saved has a telling effect when taken over a period. We find that the checking of additions, multiplications, and other calculations is best left to a specialist in records, so that cards or worksheets can leave the laboratory benches as early as possible, and the operatives can devote more of their time to their own special tasks. It also reduces the "rush hour" for typists at the end of the day.

Analytical Reports

We can now turn to methods of rendering reports of the proximate analysis to our clients, for this sheds some light on its significance.

The first complication in this work is caused by the moisture. As was stated earlier, coal that is apparently bone-dry shows a loss at 105°C., mainly due to the loss of moisture, and we referred to this as combined or inherent moisture. With most coals, however, this is not the only moisture that we have to deal with, for the coal can and does acquire additional moisture in many ways—from water in the underground workings, from wet-washing processes, from the weather and from other causes. All this moisture is external, adventitious, extraneous, or free, and if the coal is exposed to the air it dries off. No heating is necessary to remove this free moisture, and when the coal is thus dried it is left with its original combined moisture, which can only be removed by heating. In general, this free moisture must be dried off before the crushing machines used for the preparation of the laboratory sample can work satisfactorily.

Here is another well-known fact that complicates the issue. Suppose we have a 10-lb. sample of apparently bone-dry coal, crushed to pass a $\frac{3}{16}$ in. mesh, and heat part of it to 105°C. without further treatment. It will be found to show a moisture loss which we express as a percentage. Now suppose we take a further part of the sample and crush it until fine enough to pass a No. 72 sieve (60 mesh). If this fine coal is heated to 105°C. it will also show a moisture loss which we again express as a percentage. We now have two percentage losses at 105°C., the only difference between the two experiments being the extra grinding. The complicating factor is that the loss shown by the finely ground coal will be less than the loss shown by the unground coal. The inference is that the coal loses something during the crushing process, which may be either occluded gas or free moisture, lying deep down in the coal fragments. The difference between the two moisture losses is often quite large and cannot be neglected. Now, for all the tests of the proximate analysis and most other laboratory tests on coal, it is essential and specified that the samples shall be crushed to pass a No. 72 sieve. This means that the moisture loss determined in these finely ground samples is always at least a little lower than the truth.

So we have to reckon with two complicating factors:

(1) The free moisture and the necessity to remove it before fine crushing.

(2) The moisture loss incurred during the crushing, even with apparently dry coals.

The coal, after crushing through a No. 72 sieve, will come into equilibrium with the atmosphere and its moisture content will remain constant, subject only to minor alterations due to alterations in the humidity of the air. This is the material that we analysts refer to when we talk or write about "air-dried coal," and is the coal used for those analyses that are reported on the "air-dried basis," or "basis, air-dried." Such an analysis is not, in any sense of the word, a true picture of the coal "as received" by the buyer or "as delivered" or "as shipped" or "as weighed" or "as sampled," being always lower in moisture than is the truth, and, as will be seen later, somewhat higher in the other components. In other words, if the receiver wants to know, out of each 100 tons of coal purchased, how many tons of moisture and how many tons of ash are included in the sale, the proximate analysis as determined in the finely ground, air-dried coal will not give him the required information. The only exceptions to this state of affairs are the buyers of ready ground pulverized fuel or any grade of coal fine enough to pass No. 72 sieve, provided the coal is not subsequently wetted, for then it would have to be dried before testing and one of the complications would be restored.

The solution of this problem is twofold.

(1) Where the coal is reasonably dry a special coarse-mesh sample is prepared and the loss at 105°C. determined in the larger quantity specified by B.S.I.

(2) Where the coal—such as washed coal—is visibly wet, a special sample must be taken for moisture only. Where the maximum size of the coal is not great—say $\frac{1}{4}$ in. or slightly more—especially in graded coals, the moisture sample is better left uncrushed and the "air drying loss" determined on portions of 10 lb. or so, contained in suitable metal trays. After air drying, this sample is crushed to pass, say, $\frac{3}{16}$ in. mesh, and the remaining moisture determined as in (1). The total moisture "as sampled" is *not* the sum of the air-drying loss and the moisture determined after air drying, but is calculated by—

$$M = m_1 + m_2\left(1 - \frac{m_1}{100}\right)$$

where M = total moisture "as sampled."
m_1 = percentage loss on air drying.
m_2 = percentage loss at 105°C. determined in the sample after air drying.

This special moisture determination—which is so often omitted—establishes the total moisture in the coal "as received," "as delivered," "as shipped," "as weighed," or "as sampled," whichever term may be considered applicable.

We now have the proximate analysis "air-dried," and the moisture "as sampled," &c., and to obtain the complete analysis of the coal "as sampled" it is necessary to recalculate the air-dried analysis to the higher moisture basis.

Before passing on to the details of this and other calculations—which, after all, are really very simple—we must ask those who are well versed in their use to bear with us in patience. It must be remembered that we are writing not only for those who have—as many of us have—the opportunity of using them every day, but also for those who have not. Our experience shows that the various bases on which coal tests can be reported are not by any means universally understood by the coal trade.

We illustrate here with an example:

	Proximate analysis. "Air-dried."
Moisture	2.0%
Ash	8.0%
Volatile matter	30.0%
Fixed carbon	60.0%
	100.0%

Moisture as sampled, 3.0%.
Required the proximate analysis "as sampled."
Rule: Multiply each component by—
$$\frac{\text{100 minus moisture "as sampled."}}{\text{100 minus moisture "air dried."}}$$

	Proximate analysis. "As sampled."
Moisture	3.0%
Ash $8.0 \times \frac{97}{98}$	7.9%
Volatile matter $30.0 \times \frac{97}{98}$	29.7%
Fixed carbon (by difference)	59.4%
	100.0%

The alteration caused by only 1.0% difference in the two moistures is not very great, as you can see, but when washed coals with very high total moistures are involved the change is considerable. Take the same "air-dried" proximate analysis again, but this time let us suppose it was a washed coal and that the moisture "as sampled" was 12.0%. Following the rule already given the proximate analysis "as sampled" is calculated from the proximate analysis "air-dried" to be:

	Proximate analysis. "As sampled."
Moisture	12.0%
Ash $8.0 \times \frac{88}{98}$	7.2%
Volatile matter $30.0 \times \frac{88}{98}$	26.9%
Fixed carbon	53.1%
	100.0

Note in particular how much the volatile matter has been reduced. So much so that it now gives a completely false picture of the coal. A helpful thought here is that the proximate analysis "as sampled" for washed coals is really the analysis of a mixture of coal and water. Let us not forget that in actual use the coal will behave as such a mixture, losing the surplus water at an early stage of heating.

This last example should have helped us to lead up to a more friendly feeling for the air-dried proximate, for some of you, particularly the receivers, may already be thinking that the "air-dried" analysis emphasizes the good qualities of the coal rather than the bad.

The "air-dried" proximate is the correct analysis to use when comparing coals from day to day, cargo to cargo, year to year. It completely discounts the effects of free moisture, no matter how acquired, and brings the coals to a common level for comparison. Most British coal is sold with the understanding and the expectation by the buyer that he will receive deliveries equal to, or reasonably near to, the quality represented by the seller. Contracts incorporating bonus or penalty clauses for rise or fall of quality are not part of the national sales policy, and, in fact, they are to all intents and purposes illegal. This is in sharp contradistinction to Continental and U.S.A. commercial practice. One result of this sales policy is that in this

country the reporting of coal analyses "as sampled" is by no means universal. A large proportion of our reports are thus sent out on the "air-dried" coal with the moisture "as sampled" as a footnote. This type of report serves two purposes. It illustrates the variability or the constancy of the coal from day to day, and also brings out sharply the variations or otherwise of the total moisture, which can often be associated with weather conditions during transport or loading operations. Then, again, bear this in mind, that once the coal has been weighed and thus the invoice price fixed, any additional moisture—except in so far as it is anti-calorific—is not of interest to the receiver, since he does not have to pay for it. Many coals are weighed warm and dry immediately on leaving the pit, but can become somewhat damp if subjected to rain or snow during transport to ports of shipment or to destination. Also the points and times of sampling are not necessarily the same as the points and times of weighing. Any moisture acquired after the coal has been weighed for invoice cannot by any stretch of the imagination be made the responsibility of the producer. It is well to remember that consideration of the "as sampled" moisture cannot very well be undertaken without also considering whether or no the time and point of sampling can be taken as coincident with the point and time of weighing, since the weight of coal delivered is inevitably influenced by the weather conditions following the weighing. For washed coals many other important factors also influence the weight.

An elaboration of the type of report showing the "air-dried" proximate plus the "as sampled" moisture is to send out the complete analysis on both bases. Where the coal is sold for combustion this may be the best method, for the combustion engineer, in addition to being inquisitive about the type or constancy of type of coal used, must also know how many calories or B.Th.U. have been thrown, dragged, pushed or blown into his hungry furnaces. Here the proximate analysis will be accompanied by the calorific value, and the only practical basis for this latter test is the "as sampled," which should amount to the same thing as "as fired."

Emerging from all this we really have:

(1) To *compare* coals—use the "air-dried" analysis.

(2) To *evaluate* coals—use the "as sampled" analysis.

But this is not all, for we analysts carry out still further calculations.

The first is to calculate to "dry" coal, but as this is merely taking the "air-dried" analysis one small stage further, we do not attach so much importance to it as we have done in the past. The only purpose is to render the comparison of the coals in ash and volatile matter—particularly the ash—slightly more acute. Little is achieved that is not achieved by the "air-dried" analysis, since the "air-dried" moisture is, for any one coal, constant within reasonable limits.

The second is to calculate to moisture and ash-free coal, and this is a calculation of some considerable importance. For this purpose we *imagine* a coal from which all the moisture and all the ash have been removed, leaving only the volatile matter and the fixed carbon. This concept of volatile matter plus fixed carbon is sometimes referred to as the *pure coal substance* or the *bone of the coal*, but this is not by any means correct, and is one of those misnomers whose use should be discontinued. Remember that the ash does not represent the original mineral matter of the coal, but only the ash of the mineral matter. Also most of the sulphur of the coal is somewhere in the volatile matter and the fixed carbon, and this sulphur may amount to 3% or more of the coal, and in general lies somewhere between 0.5% and 2%. Besides, there is another calculation that aims at correcting the proximate analysis and other tests to the real pure coal substance which we shall mention later. So to be safe, let us think only of moisture and ash-free coal, or, as we do in our daily discussions, M.A.F. coal.

What we are after is the ratio of the volatile matter to the fixed carbon, for this figure is of great utility for all manner of useful purposes, especially in comparisons and classifications. All who wish to simplify the work of selecting, discussing, or understanding coals from many different sources will do well to drill themselves in its use. The calculation goes on exactly the same lines as the previous calculation. Take the previous example:

	Proximate analysis. "Air dried." %	"As sampled." %
Moisture	2.0	3.0
Ash	8.0	7.9
Volatile matter	30.0	29.7
Fixed carbon	60.0	59.4
	100.0	100.0

The two analyses, you will remember, are one and the same coal calculated to two different bases. Taking the "air-dried" analysis there is 2% of moisture and 8% of ash, making altogether 10% of materials which, for this purpose, we regard as non-coal. The 30% of volatile matter and the 60% of fixed carbon, making 90% altogether, is moisture and ash-free coal—M.A.F. coal. The objective is to make these 90 parts of M.A.F. coal into 100 parts so as to give a ratio of volatile matter to fixed carbon, totalling a convenient 100%.

Rule.—Multiply the volatile matter by—

$$\frac{100}{100 \text{ minus (moisture, plus ash)}}$$

If you try this on the "as sampled" analysis given above you will find it works out to exactly the same result, showing how it cuts out apparent variations in the coal itself, due to variations in the moisture or the ash or both, and reveals the constancy of the M.A.F. coal.

Thus the moisture can rise or fall due to extraneous causes; the ash can rise or fall by increase or diminution of the stony impurities present, but the volatile matter in the M.A.F. coal remains reasonably constant. Thus a serious change in this figure is a matter for close inquiry.

And now you will want to know specifically what use can be made of the proximate analysis.

To us the proximate analysis is the Piccadilly Circus of all coal science. This is of particular importance from the laboratory point of view, for there it is used as the great traffic centre from which lines of inquiry appropriate to the solution of the problem may be directed.

The best method we can suggest to get a complete bird's-eye view of the position of the proximate analysis in coal testing is a brief reference to the classification of coal. In this field we find that restless, inquisitive man is no less industrious in prying into the why and the wherefore than in any other field of gain or of knowledge. One of his special pursuits is the attempt to lay down rules and laws whereby he can explain to himself the methods used when the coal seams were originated. An important step in this work is the rounding-up of the world's coals into any easily discerned, natural groups we may find. By comparing the appearance of pieces of foreign coal brought home by mariners, by listening to the tales of the sailors, by personal travel, and by the testing of anything and everything combustible, man was soon led to find the three great groups of coals:

(1) *The Lignites.*—The brown or woody coals, some of them not unlike freshly sawn lignum vitae in appearance.

(2) *The Bituminous Coals.*—Black coals that partly soften and melt when strongly heated, thus resembling bitumen—another naturally occurring combustible.

(3) *The Anthracites.*

Using the proximate analysis only, one finds rather more well-defined groups, depending for their recognition on the type of coke button, the amount of volatile matter, and the amount of combined moisture.

Another way is to group them in accordance with their gas-making and tar-yielding properties, which led to the broad divisions of fat and lean coals used on the Continent. They can also be grouped by the length of flame given when they burn: Long flame, medium flame, and short flame coals.

Still another method is to divide them by means of their suitability for various purposes. Thus—reverberatory furnace coals (long flame), gas coals, coking coals, steam coals, and domestic and central heating coals. To-day the steam coal category is, of course, a doubtful one, since modern appliances can be designed to burn almost anything. In your minds for this class, think of *best* steam coals; those with volatile matter approaching 20%. Still more elaborate classifications are possible wherein are grouped the figures obtained in various laboratory tests—calorific value, carbonization assay, swelling tests, analysis of ash, and so on, tidying the coals up into neat little bundles, all alike in any one or more features and looking for further relationships between the various bundles.

The earliest serious scientific classification of coal was carried out by the illustrious Regnault and modified later by the French metallurgist Gruner. Still later it was modified by the late Professor Bone,* and Table II, giving the whole scheme, is taken from his book. Please note, with great care, that all the figures are expressed on the M.A.F. coal and also that the volatile matter was determined at 900°C., making the results 1 or 2% too low compared with the modern test at 965°C. We confess a liking for this classification mainly because it is simple, and tallies in full with the results of our everyday work during almost two decades. (*To be concluded*)

* *Coal and its Scientific Uses*, W. A. Bone, 1922.

TABLE II.—THE REGNAULT-GRÜNER CLASSIFICATION OF COALS (as REVISED BY BONE).

Genus.	Class.	Chief uses.	Percentage composition. C.	H.	O + N + S.	% Volatiles at 900°C.	% Fixed carbon.	Character of carbonaceous residue.
A.—Lignites	Non-caking	—	60 to 75	About 5.0	20 to 35	Above 45	Below 55	Non-coherent.
B.—Bituminous	(1) Non-caking, long flame.	Reverberatory furnaces	75 to 80	4.5 to 5.5	15 to 20	40 to 45	55 to 60	Non-coherent.
	(2) Caking, long flame	Gas-making	80 to 85	About 5.6	10 to 15	32 to 40	60 to 68	Very porous coke.
	(3) Hard coking	Coke manufacture	84 to 89	5.0 to 5.6	5.5 to 11.0	26 to 32	68 to 74	Dense coke.
	(4) Hard coking, short flame	Coke manufacture and steam raising	88 to 90	4.5 to 5.5	5.5 to 6.5	18 to 26	74 to 82	Very dense coke.
B.C.—Semi-bituminous	Non-caking short flame	Steam raising	90 to 92	4.0 to 4.5	4.0 to 5.5	15 to 20	80 to 85	Weakly caking or non-coherent.
C.—Anthracitic and anthracites	(1) Anthracitic, non-caking.	Steam raising	92 to 94	3.0 to 4.0	3.0 to 4.5	8 to 15	85 to 92	Pulverulent.
	(2) Anthracites, non-caking	Domestic and central heating; malting kilns				Below 8	Above 92	

All the numerical data in the above table refer to the dry ashless coal.

Gas Products Prices

The London Market Mar. 1.

The chief item of interest in connexion with the Coal Tar Products market is the issue of a new Government Order, the Coal Tar Products Prices Order, 1942 (S. R. & O., 1942, No. 2509), which came into force on Jan. 1.

All Coal Tar Products are in good demand, and Pitch in the London area remains about 45s.

The Provinces Mar. 1.

The average prices of gas-works products during the week were: Pitch and Crude Tar,* Toluole, naked, North, 90's, 1s. 10d., pure, 2s. 5d. (controlled by the Control of Toluene No. 2 Order, July 3, 1941, which fixes the maximum price at which this material may be sold). Naphtha and Xylol controlled by the Coal Tar, Naphtha and Xylol Order, 1942, dated Dec. 7, 1942, and operative from Dec. 21. Carbolic acid, 60's, naphthalene, and anthracene controlled by the Coal Tar Products Prices Order S. R. & O. 2509, dated Dec. 7, 1942, and operative from Jan. 1, 1943. Filtered heavy oil (min. gr. 1,080), 7½d. to 8d. Creosote oil has been generally controlled as to direction and price for some time past. Current value—fuel grades 5d. to 5½d.; timber preservation and other purposes 4¾d. to 6d.

* In regard to pitch and crude tar prices we would ask readers to refer to the editorial note on p. 396 of the "JOURNAL" for Sept. 10, 1941.

Tar Products in Scotland Feb. 27.

Steady conditions prevail with deliveries satisfactory. Refined tar controlled. Value is 4½d. per gallon *ex* Works, naked. Creosote oil: Specification oil, 6½d. to 7d.; low gravity, 7½d. to 7¾d.; neutral oil, 6d. to 6½d.; hydrogenation oil, 5⅞d. per gallon; all *ex* Works in bulk. Refined cresylic acid is changing hands at 3s. 6d. to 4s. 6d. per gallon *ex* Works, naked, according to quality. Crude naphtha: 6½d. to 7d. per gallon. Solvent naphtha: Basic prices delivered in bulk, 90/160 grade 2s. 8d., and 90/190 Heavy naphtha, Unrectified, 1s. 10½d.; Rectified, 2s. 3d. per gallon. Pyridine: 90/160 grade, 13s., and 90/140 grade, 15s. per gallon.

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GAS STOCKS AND SHARES

Markets were quiet at the opening last week, but brightened up later on the more favourable turn of events in Tunisia, although there was no increase in the general volume of business. The Gas Market maintained all its previous gains, which, as reported earlier during the month, had been on a larger scale than for a long time past. But here again the number of transactions was on the small side. There is still very little ordinary stock on offer, although a parcel of £10,000 Gas Light 3½% maximum stock is available at 66 and a holding may turn out a good lock-up. It will be remembered that no dividend had been paid on this stock since June, 1940, until the 1½% recommended for 1942. There are also 5,000 £1 ordinary shares of the United Kingdom Gas Corporation still on offer at 19s. 9d., yielding £5 1s.%. Among preference issues, parcels of Gas Light 4% and South Metropolitan 4%, both at 94 to yield 4¼%, are attractive.

The following price changes, apart from *ex div.* markings, were made during the week:

PROVINCIAL EXCHANGES

Weston-Super-Mare Ord.	99—101	+2½
Ditto 4 p.c. Deb.	99—101	+3½

OFFICIAL LIST

Associated Gas & Water Deferred	19/—20/-	+1/3d.
Bournemouth 4 p.c. Deb.	102—107	+2
Colombo 7 p.c. Pref.	21/—23/-	+1/-
Gas Light 3½ p.c. max.	63—66	—1
Ditto 3½ p.c. Red. Deb.	105—109	+1
Mid-Southern 4 p.c. Pref.	87—92	+2
Primitiva Holdings Ord.	11/6—13/6	—/6d.
Severn Valley 4½ p.c. Cum. Pref. ...	17/—19/-	+/6d.
Tottenham Ord.	100—105	+3
United Kingdom 4½ p.c. 1st Cum. Pref.	18/6—20/6	+/6d.
Wandsworth Cons.	102—107	+2

SUPPLEMENTARY LIST

Mid-Southern "A" Cons.	80—85	+7½

Quotations on the London and Provincial Stock Exchanges

OFFICIAL LIST

Issue. £	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations Feb. 26.
1,767,439	Sept. 7	5	5	Alliance & Dublin Ord. ...	95—105
374 000	Dec. 28	4	4	Do. 4 p.c. Deb.	98—103
583,407	Nov. 9	5	5	Assocd. Gas & Water U'd'ts Ord.	19/—20/-
388,938	"	—	—	Do. Deferred	19-/—20/-
500.000	"	4½	4½	Do. 4½ p.c. Red. Cum. Pref.	19/—20/-
535,545	"	4	4	Do. 4 p.c. Red. Cum Pref.	18/6—19/6
341,966	"	4	4	Do. 4 p.c. Irred. Cum. Pref.	16-/—17/-
561,370	Feb. 22	7	7	Barnet Ord. 7 p.c. " ...	135—140*
300,000	Oct. 5	1/9⅜	1/4⅜	Bombay, Ltd.	21/6—22/6
690,407	Feb. 15	7	7	Bournemouth 7 p.c.max. ...	135—140
362,025	Dec. 14	4	4	Do. 4 p.c. Deb. ...	102—107
659,955	Sept. 7	2½	2½	Brighton, &c., 5 p.c. Con. ...	75—80
855,000	" 28	6	6	Brit. Gas Light Ord.	95—100
545,000	Dec. 21	5½	5½	Do. 5½ p.c. 'B' Cum. Pref.	110—115
120,000	" 14	4	4	Do. 4 p.c. Red. Deb.	92—97
10,000	Nov. 6 '33	6	4	Cape Town, Ltd., 4½ p.c. Cu. Pf.	35/—55/-
626,860	Feb. 8	6	6	Cardiff Con. Ord.	102—107
24,500	Oct. 26	7	7	Colombo 7 p.c. Pref.	21/—23/-
764,169	Sept. 28	-/9.56	-/9.56	Colonial Gas Assn. Ltd. Ord. ...	¼—¼
400,000	"	1/3.298	1/3.298	Do 8 p.c. Pref. ...	¼—¼
1,748,090	July 22 '40	2	3	Commercial Ord.	56—61
620,000	Dec. 7	3	3	Do. 3 p.c. Deb.	60—65
286,344	Feb. 15	5	5	Do. 5 p.c. Deb.	103—108
807,560	" 22	6	6	Croydon sliding scale	110—115*
644,590	"	5	5	Do. max. div.	90—95*
620,385	Dec. 28	5	5	Do. 5 p.c. Perp. Deb. ...	120—125
179,500	Feb. 22	5	5	East Surrey 'B,' 5 p.c.	83—88*
176,461	Dec. 28	5	5	Do. 5 p.c. Deb. (Irred.)...	120—125
250,000	Nov. 9	6	4	Gas Consolidation Ord. 'B' ...	17-/—18/-
250,000	"	4	4	Do. 4 p.c. Red. Cum. Pref.	18/—20/-
19.107,811	Feb. 15	—	†1	Gas Light & Coke Ord. ...	16/3—17/3d
2,600,000	"	—	†1½	Do. 3½ p.c. max.	63—66
4,477,106	"	4	4	Do. 4 p.c. Con. Pref. ...	90—95
2,993,000	"	3½	3½	Do. 3½ p.c. Red. Pref. ...	90—95
8,602,497	Nov. 30	3	3	Do. 3 p.c. Con. Deb. ...	85—88
3,642,770	"	5	5	Do. 5 p.c. Red. Deb. ...	106—110
3,500,000	"	4½	4½	Do. 4½ p.c. Red. Deb. ...	105—109
700,000	Sept. 14	3½	3½	Do. 3½ Red. Deb. ...	94—97
5,600,000	May 13 '40	4	8	Imperial Continental Cap. ...	76—81
43,820	Jan. 25	3½	3½	Do. 3½ p.c. Red. Deb. ...	95—100
231,978	Feb. 22	5	5	M.S. Utility 'C' Cons.	84—89*
918,657	"	4	4	4 p.c. Cons. Pref.	87—92*
675,000	Nov. 16	‡4	‡4	Montevideo, Ltd.	93—98
300,000	Dec. 14	7	9	Oriental, Ltd.	97—102
368,537	June 15	3½	2½†	Plymouth & Stonehouse 5 p.c.	70—75
621,667	Feb. 8	7½	7½	Portsmouth & Gosport Cons.	103—108
2,381,363	May 18	—	4†	Primitiva Holdings, Ltd. Ord.	11/6—13/6
233,900	Dec. 14	3½	3½	Do. 6½ p.c. Red. Cum. Pref.	96—101
648,999	Sept. 7	1/1½	1/1½	Severn Val. Gas Cor. Ld. Ord.	18/6—20/6
597,972	"	4½	4½	Do. 4½ p.c. Cum. Pref. ...	17/—19/-
2,528,714	Aug. 24	1/-	7½	South East'n Gas Cn. Ld. Ord.	17/6—18/6
1,000,000	"	-/10½	-/10½	Do. 4½ p.c. Red. Cum. Pref.	18/—20/-
1,068,869	"	4	4	Do 4 p.c. Irred. Cum. Pref.	15/6—17/6
6,709,895	Feb. 22	—	†1	South Met. Ord.	73—76*
1,135,812	"	—	†6	Do. 6 p.c. Irred. Pref. ...	118—123*
850,000	"	—	†4	Do. 4 p.c. Irred. Pref. ...	88—93*
1,895,445	Dec. 28	3	3	Do. 3 p.c. Perp. Deb. ...	82—87
1,000,000	Jan. 11	5	5	Do. 5 p.c. Red. Deb. ...	102—107
1,543,795	Feb. 8	4	4	South Suburban Ord. 5 p.c ...	88—93
$12,825	"	5	5	Do. 5 p.c. Perp. Pref. ...	97—102
$00,000	"	4	4	Do. 4 p.c. Perp. Pref. ...	85—90
250,000	"	3½	3½	Do. 3½ p.c. Red. Pref. ...	90—95
888,587	Dec. 14	3	5	Do. 5 p.c. Perp. Deb. ...	120—125
750,541	Feb. 8	2	6	Southampton Ord.	77—82
350,000	" 15	5½	5½	Swansea 5½ p.c. Red. Pref. ...	95—100
1,076,495	Aug. 17	5	5	Tottenham & District Ord. ...	100—105
338,555	"	5	5	Do. 5 p.c. Pref.	97—102
453,380	Dec. 7	4	4	Do. 4 p.c. Perp. Deb. ...	97—102
1,247,505	Nov. 9	6	4	U. Kingdom Gas Cor. Ord. ...	18/9—19/9
1,085,952	Nov. 16	4½	4½	Do. 4½ p.c. 1st Cum. Pref. ...	18/6—20/6
772,709	"	4	4	Do. 4 p.c. 1st Red. Cum.Pref.	18/—20/-
745,263	Dec. 14	4½	4½	Do. 4½ p.c. 2nd Non.Cum. Pf.	15/6—17/6
1,200,000	Sept. 14	3½	3½	Do. 3½ p.c. Red. Deb. ...	95—100
380,606	Aug. 24	6⅜	6⅜	Uxbridge, &c., 5 p.c.	113—118
1,371,138	Jan. 25	4	6	Wandsworth Consolidated ...	102—107
2,525,768	"	4	4	Do. 4 p.c. Pref.	85—90
1,343,964	Dec. 14	5	5	Do. 5 p.c. Deb.	120—125
383,745	"	4	4	Do. 4 p.c. Deb.	95—100
558,342	Feb. 22	5	5	Watford & St. Albans Ord. ...	106—111*
300,000	Dec. 7	3½	3½	Do. 3½ p.c. Red. Deb. ...	90—95

SUPPLEMENTARY LIST

Issue. £	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations Feb. 26.
351,685	Dec. 14	5	5	Brighton, &c., 5 p.c. Perp. Deb.	115—120
415,250	"	4	4	Bristol Gas Co., 4 p.c. New Deb.	97—102
140,205	Feb. 15	7	7	Cambridge, &c., 7 p.c. Cons. 'B'	132—137
295,932	Aug. 17	5	5	Cheltenham, 5 p.c. Cons.Ord....	95—100
42,500	Dec. 14	4	4	Do. 4 p.c. Perp. Deb....	95—100
150,000	Feb. 22	4	4	Croydon Gas, 4 p.c. Pref. (Irr.)	85—90
130,000	Dec. 28	4	4	Do. 4 p.c. Deb. ...	97—102
146,700	Feb. 22	5½	5½	East Surrey, 5½ p.c. Pref. 'A' ...	95—100
53,220	" 9	6	6	Do. 6 p.c. Cum. Pref. ...	115—120
...	Aug. 19 '40	6	4	Eastbourne, 'B' 3½ p.c.... ...	42—47
117,425	Feb. 5 '40	8	8	East Wight Cons. 5 p.c. ...	65—70
239,135	Nov. 9	5	5	Gas Consolidation 'A' Ord. (£1)	15-/—17/-
156,600	Feb. 15	5	5	Hampton C't, 5 p.c. Cons. Ord.	95—100
18,000	Dec. 29'41	3½	3½	Malta & Med'n., 7 p.c. 1st Pref.	30—40
10,845	June 30'41	3½	3½	Do. 7½ p.c. 2nd Pref.	30—40
50,000	Feb. 22	£5 4 6	£5 4 6	Mid. South. Util., 'A' Cons. 5 p.c.	80—85
65,000	"	5	5	North Middlesex, 5 p.c. Pref. ...	95—100
70,000	Sept. 14	5	5	Plymouth & Stone., 5 p.c. Deb.	110—115
76,501	Dec. 21	4	4	Reading, 4 p.c. Perp. Deb. ...	95—100
74,777	Sept. 30	4	4	Romford, 4 p.c. Debs. (Reg.) ...	95—100
21,000	Dec. 7	5	5	Slough, 5 p.c. Perp. Deb. ...	115—120
211,740	" 14	5	5	Southampton, 5 p.c. Red. Deb.	95—100
363,575	Jan. 4	5	5	Tottenham, 5 p.c. Reg. Red. Mt.	103—108
202,019	Aug. 24	7⅛	7⅛	Tunbridge Wells, 4 p.c. Scale ...	119—124
135,257	Dec. 7	5	5	Uxbridge &c., 5 p.c. Perp. Deb.	120—125

PROVINCIAL EXCHANGES

					Quotations Feb. 19.
804,948	Sept. 28	5	5	Bath Cons.	97—100
122,577	Aug. 17	6	5	Blyth 5 p.c Ord.	103—104
1,667,250	Feb. 15	5	5	Bristol, 5 p.c. max.	108—110
120,420	Dec. 14	4	4	Do. 1st 4 p.c. Deb.	101½—103½
415,250	"	4	4	Do. 2nd 4 p.c. Deb.	100½—102½
328,790	"	5	5	Do. 5 p.c. Deb.	112—117
157,150	Feb. 1	5	6½	Chester 5 p.c. Ord.	98—102
92,500	Dec. 14	4	4	Do. 4 p.c. Pref.	79—81
36,430	"	3½	3½	Do. 3½ p.c. Deb.	78—82
41,890	"	4	4	Do. 4 p.c. Red. Deb. ...	98—100
542,270	Aug. 17	9	6	Derby Cons.	115—120
55,000	June 21	4	4	Do. 4 p.c. Deb.	95—100
10,000	Aug. 10	10	10	Great Grimsby 'A' Ord.	155—165
6,500	"	10	10	Do. 'B' Ord.	155—165
79,000	"	10	10	Do. 'C' Ord.	145—155
732,000	Feb. 15	4	4	Hartlepool G. & W. Cn. & New	84—86
2,167,410	" 10	6	5	Liverpool 5 p.c. Ord.	105—106
245,500	Dec. 21	5	5	Do. 5 p.c. Red. Pref.	100—104
306,083	July 15	4	4	Do. 4 p.c. Deb.	100—102
20,000	June 22	5	5	Long Eaton 5 p.c. Pref.	9—11
80,000	"	5	5	Do. 5 p.c. Deb.	95—100
2,430,267	Feb. 8	5½	5½	Newcastle and Gateshead Con.	22/3—22/9
682,856	"	4	4	Do. 4 p.c. Pref.	93¼—94½
776,706	Dec. 28	3½	3½	Do. 3½ p.c. Deb.	93½—94½
277,285	Nov. 2	5	5	Do. 5 p.c. Deb. '43 ...	99—101
13,200	Sept. 16	8½	7	Pontyp'l Gas & W. 10 p.c. 'A'	11½—12½
13,600	"	6	5	Do. 7 p.c. 'B'	9½—10½
40,000	"	5	6	Do. 7 p.c. 'C'	9½—10½
106,280	Aug. 10	10	10	Preston 'A' 10 p.c.	150—160
188,219	"	7	7	Do. 'B' 7 p.c.	109—119
1,806,339	Aug. 24	6½	6½	Sheffield Cons.	130—133
95,000	Jan. 4	4	4	Do. 4 p.c. Deb.	98—100
332,351	Sept. 21	6	6	Sunderland 6 p.c. max. ...	112—113
192,150	Feb. 8	5	5	Weston-super-Mare Cons. ...	99—101
64,338	Jan. 4	4	4	Do. 4 p.c. Deb.	99—101
33,340	"	7½	7½	Do. 7½ p.c. Deb.	142—147

o —The quotation is per £1 of Stock. * Ex. div. † For year. ‡ Paid free of income-tax.